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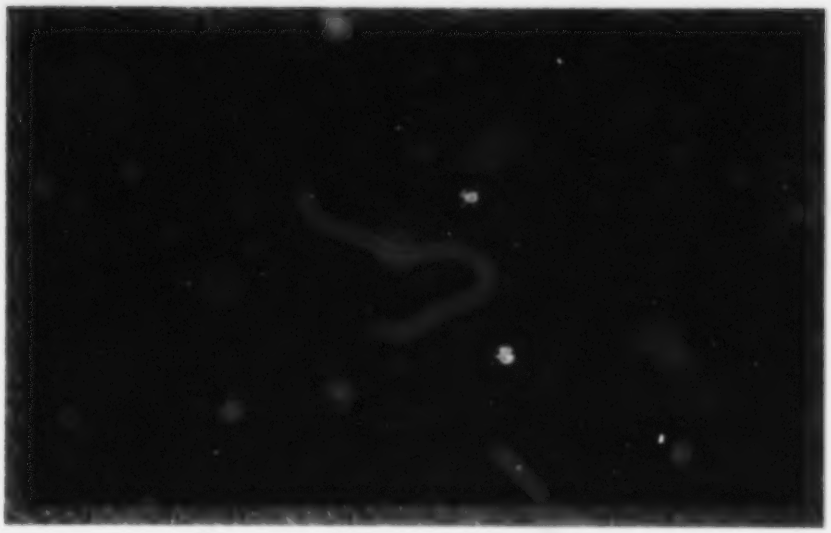

CENTRE DE RECHERCHE SUR LES TRANSPORTS

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THE RELATIONSHIP BETWEEN TRANSPORTATION INVESTMENTS AND THE LAND-USE CHANGES: A REVIEW OF THE LITERATURE

by

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ABSTRACT

The paper reviews the American and Canadian literature dealing with the effects of transportation facilities on urban land use and value, and the evaluation and control of these impacts, from a town planning point of view.

In the first part, different approaches to the Land-Use/Transportation problem are singled out showing different points of view: the historical, theoretical, and empirical approaches. The most important experiences of rapid transit impact studies are then analyzed: Toronto, Philadelphia, San Francisco, Washington, and Atlanta. The review then analyzes the evolution of the debate in the last 20 years and the numerous factors involved with the subject: technological, economic, environmental, political, etc.

The second part compares critically the different approaches, discussing the strengths and weaknesses of the methods of analysis and of the techniques of control of the impacts, stressing the current level of the debate and the perspectives for the future.

Key words : Land Use/Transportation; impact; effects of transportation; bibliography; Canadian literature; American literature.

RÉSUMÉ

Cette étude fait une revue de la littérature américaine et canadienne portant sur les effets des infrastructures de transport sur l'emploi et la valeur du territoire avoisinant, et sur l'évaluation et le contrôle des impacts relatifs, du point de vue de l'aménagement du territoire.

Dans la première partie sont individualisées les différentes approches au problème de la relation transports-planification urbaine, de différents points de vue: historique, théorique, empirique. Après on analyse les expériences plus importantes des études sur les Effets Induits par les Transports en commun en site propre : Toronto, Philadelphie, San Francisco, Washington et Atlanta. L'étude analyse donc l'évolution du débat pendant les derniers 20 ans et les nombreux facteurs et enjeux du sujet : technologiques, économiques, de l'environnement, politiques, etc.

La seconde partie fait une comparaison critique des différentes approches discutant les points forts et les faiblesses des méthodes d'analyse et des techniques de contrôle des impacts, illustrant le niveau actuel du débat et les perspectives futures.

Mots-clés : transports-planification; impact; effets des choix; bibliographie; littérature canadienne; littérature américaine.

INTRODUCTION

What happens after the opening of a new transit line? What are the effects of transportation investments (i.e. new highways, expressways, busways, subways, etc.) on land use changes? What about land values? What, and how large are the impacts of new transportation facilities on the urban environment?

These and other questions are the subject of the study. The report documents the state-of-the-art of the research in the North American experience.

It seems to be an obvious consideration about the relationship between transportation and land use, so simply, but not trivial, that there is no general agreement on it. The land use pattern (i.e. design of site, zoning, density, ...) determines intensity and characteristics of travel between areas, and so influences the transportation system; in turn, the transportation system affects the convenience and the opportunities of land use, becoming an important factor of land use and value change: a precious tool in the hand of the planner.

But, on the contrary, there is a lack of consideration of each towards each other, a gap, either in planning practice or in managing policies, that ignores this relationship and the meaning of coordination in land use and transportation planning and managing; it is due to the separation of competences, between sectors, and the level of government (municipal, provincial, national).

The basic hypotheses of the research are, thus:

- improvement in transit service can lead to reduction of energy consumption, environmental pollution and congestion, less dependence on automobile, and a better quality of the urban environment;
- with adequate transportation policies it is also possible to influence the existing spatial structure of land use and the characteristics of urban changes;
- moreover, through land use planning it is possible to influence the location of activities and residences, and then, the characteristics of traffic and trips;

- the coordination of policies and the joint planning of the transportation system and the land-use system are becoming more and more important to give effectiveness to the public policy in controlling the transformation process, both at the urban and regional levels.

Goals of the research are, then:

1. To review the literature dealing with the issue of the land use-transportation relationship, analyzing the factors involved, the existing problems, and the perspectives of evolution of the debate.
2. To document the history and the conditions that have led to some realizations and experiences, or interesting case studies in North American cities.
3. To analyze the methodologies of analysis, forecast, and control of the impacts of transportation improvements on land use changes.
4. To compare the issues with the European experiences.

The research has been carried out either by comparing the different approaches expressed in some basic textbooks and manuals as basic references of the latest debate (see Tab. 1); or by retrieving information about the literature employing different information systems (see next paragraph "Bibliographies and Sources"); or by gathering information analyzing directly some case studies; or, finally, by discussing with experts and selected people subjects of the research, having suggestions and guidance.

Table 1

Handbooks, and Basic Textbooks

BOYCE et al. (1970)
MEYER J. (1971)
HUTCHINSON (1974)
RTAC (1977)
MORLOCK (1978)
ALTSHULER (1979)
MANHEIM (1979)
DICKEY (1983)
MEYER M.-MILLER (1984)
CUTA (1985)

BIBLIOGRAPHIES AND SOURCES

In addition to the references contained in the basic textbooks and in each specialized reference, some other sources of information have been consulted. Interesting different points of view about some aspects of the subject are the selected bibliographies of the "Vance Bibliographies", and of "The Council of Planning Librarians", Monticello, Illinois (**Kleiber-Hetu, 1985; Wolf, 1979; Reid, 1977**). Other sources of information deal more specifically with references published in Europe or other countries, for example, the bulletins of **The Chartered Institute of Transport (1977)**, or **The British Council (1986)**.

Some authors present a list of basic references in transportation planning and all related fields (**Branch, 1970; Rakowski, 1976; JHK-UMTA, 1976**). They are useful for finding out the basic textbooks on various topics and for locating the addresses of the most important agencies and research centres involved with the subject. The guide of **Fletcher and Davis (1975)** is very useful in this field. It contains, together with a list of basic textbooks, information on the most important agencies in the transportation field, the data they can provide, and how the information retrieval system of the most important governmental agencies works.

Among the selected bibliographies, few of them deal specifically with the subject of the research (**Trygg** and **Sgourakis, 1977; Dickey, 1976;** and **Rawson, 1983**). The first one was prepared during the survey of the U.S. Department of Transportation about the land use impacts of rapid transit (**Knight** and **Trygg, 1977**) and contains a review of the experiences and case studies at that time. The second one deals with the employment of the Urban Land Use Models in transportation planning.

Finally, precious is the work of **Rawson (1983)** which reports a selected annotated bibliography about the impact of transportation facilities, the evaluation of related benefits, and the techniques of Value-Capture Mechanisms.

Nevertheless, one of the most useful tools in locating updated references on the subject of the research has been the Information Retrieval System of the Urban Mass Transportation Administration **(UMTRIS, 1986)**; consultation of which has made possible the comparison of the results of surveys and research on the effects of new transit lines in America and Canada.

Table 2

Bibliographies and Sources

BRANCH (1970)
FLETCHER-DAVIS (1975)
RAKOWSKY (1976)
JKH-UMTA (1976)
DICKEY (1976)
THE CHARTERED INSTITUTE OF TRANSPORTATION (1977)
TRYGG-SGOURAKIS (1977)
REID (1977)
HICKOK-CORTELYOU (1979)
STARBUCK (1979)
WOLF (1979)
RAWSON (1983)
KLEIBER-HETU (1985)
THE BRITISH COUNCIL (1986)
UMTRIS (1986)

1. REVIEW OF THE LITERATURE

The existence of an effective relationship between land use and transportation has been demonstrated in different ways, either theoretically or empirically.

The Canadian Transit Handbook **(CUTA, 1985)** singles out three different approaches to the analysis of the relationship; these constitute different lines of research: the historical, theoretical, and empirical studies (Chapter 1).

Moreover a large production of studies has been developed from the end of the 60's analyzing the impact of new transit lines on land use and value in real case studies and experiences (Chapter 2).

1.1 Urban Transportation Historical Studies

Many authors have developed historical research about the transformation of cities that occurred between 1850 and 1915 in relation to the technological changes in urban transportation. The studies also analyze, from different points of view, the changes of the urban shape and density, the location of residences and activities, the land values, the social and economic transformations.

Owen (1972 and 1976), Blumenfeld (1978), Schaeffer-Sclar (1975) show the evolution of urbanization and the relationships between the density, extension, and accessibility phenomena, from the pedestrian city, to the city of the horse-drawn omnibuses, of the electric streetcar, and of the automobile era, explaining the necessity of joint design of the transportation network and the urban plan of the cities.

Among the urban studies, few authors analyze the role of transportation in shaping urban form; exemplary are the studies of **Fogelson (1967)** and **Banham (1971)** about Los Angeles; **Cheape (1980)** about

urban public transit in New York, Boston and Philadelphia; **Stelter** and **Artibise (1982)** about the building process of the Canadian cities. But there is increasing interest in the analysis of the role of transportation in urban growth coming from the classical urban studies and history, as in the work of S.E. Rasmussen about London, or W. Hegemann about Berlin, or the histories of P. Lavedan, L. Mumford or L. Benevolo, which have stimulated the debate and the research.

Some studies do suggest the link between transport and the economic structure of the cities. Moses and Williamson in the article "The Location of Economic Activities in Cities" published in 1967 **(Moses, 1981)** propose a history of transportation effects in Chicago, from the earliest years of the nineteenth century to the present. **Chinitz (1960)** analyzes freight transport in the New York region and argues that the development of the truck allowed the suburbanization of employment and factories, since firms, dependent on cheap, reliable freight service, no longer had to be located near railyards or ports, which historically have been in the central city.

Other authors record transportation innovations and their multiple impacts, for instance **Taylor (1966)** in the article "The Beginning of Mass Transportation in Urban America", **DeWees (1976)**, and others.

The work of **Warner (1962)** is one of the most interesting on urban studies. He analyzes the role of streetcars in the process of growth in Boston during the late 1800's. He singles out three phases of the growth:

1) The pedestrian city of the 1800, dense and restricted within a two-mile radius;

2) The peripheral towns in 1850, within a three-mile radius, expanded by the first horse car line;

3) The new suburbs in 1900, within a 10-mile radius, created by the new transportation network of electric streetcars.

As of 1870 in the Boston area, the new transport technologies provided new available land for middle and working class housing, thus affecting the transformation of the external, agricultural land, more than the pre-existent, dense, pedestrian city.

Kellett (1969) analyzes the influence of the growing railways in the life of the British cities between 1830 and 1900 by examining five major cities: London, Liverpool, Manchester, Birmingham, and Glasgow. The introduction of the new transportation network within each town, and the construction of the approach line and terminus near the city center had to deal with the high land value of the central area and the property system, affecting in turn the urban land market, the shaping of the inner districts and suburbs, and the social geography of the cities.

According to **McKay (1984)**, the urban growth in America has been stimulated by the regular urban grid plan and the new transportation technologies. Besides, by examining the growth of the European electric tramway industry between 1890 and 1910, he shows the impacts of the urban mass transit on the shape of the suburbs and cities, the "spread" of population, the search for a sound and economic house, and also the expanding leisure time activities **(McKay, 1976)**. By analyzing the Manchester and Brussels cases, he notices that:

1) Tramways were not simply following suburban development, but they were leading that development by extending their service before a demand existed.

2) As tramways fostered a decentralization and spreading out of residential areas, they also tended to concentrate commercial and administrative activities in a small and quite compact, centrally located business district.

3) Moreover, electric tramways had a strong effect on land values, increasing the price of land located on the fringes and in the emerging central business district.

Table 3

The Historical Approach

Urban History, case studies	WARNER (1962) FOGELSON (1967) BANHAM (1971) CHEAPE (1980) STELTER-ARTIBISE (1982)
Impact of Transportation	CHINITZ (1960) KELLETT (1969) MOSES (1981)
Transportation and Urban Growth	OWEN (1972) SCHAEFFER-SCLAR (1975) OWEN (1976) BLUMENFELD (1978)
History of Urban Transportation	TAYLOR (1966) DUNBAR (1967) DEWEES (1970) PERKIN (1973) McKAY (1976) McKAY (1984) PENZO (1987)

1.2 The Theoretical Relationship Between Transportation and Land Use

The theoretical relationship between Land Use and Transportation has its basis in the location theory which employs land-use models to explain the spatial structure of the locations.

The earliest attempt in this direction was made in the 1800's by **Von Thünen (1826)**, who examined the land structure of agricultural communities. His work and that of **Christaller (1933)** demonstrated the importance of transportation in the location of land uses.

Subsequently, the works of **Burgess (1925)** on the functional zones within the cities, **Hurd (1903)** on the role of transit, and **Hoyt (1939)** on the model of sectorial urban growth, pointed out the model of the relationship between land use and transportation in the cities. **Harris and Ullmann (1945)** recognized that many factors were involved in the distribution of land uses, including accessibility, economies of scale, adjacent land uses, and ability of firms to pay rents at highly accessible sites.

These models were historical, empirical and descriptive and their applicability was very limited, but they were followed by a second theoretical approach: the economic equilibrium theory.

Wingo (1960) explained that urban development is an economic phenomenon, and time is the monetary cost of transportation. **Alonso (1964), Haig (1927)** and **Hurd (1903)** demonstrate that the costs of transportation and site rental were inter-connected, as a result: "the value of urban land depends on economic rent, rent depends on location, location depends on convenience, convenience in nearness, and thus value depends on nearness", but, finally, nearness is accessibility.

Another important approach was carried out by **Guttemburg,** who explained the spatial structure of the cities on the aggregate effort of the community to overcome the friction of distance; so the transportation system holds the key to the direction in which growth proceeds.

Important for the development of theoretical locational models have been the works of **Weber (1929)** on the location of industries; **Lösch (1939)** on the location of economic activities; **Isard (1960)** and **Lowry (1964)** on the relationship between the location of residences, jobs, local services, and transportation system.

Table 4

Theoretical Studies and Models

Economic Theories of Location	VON THÜNEN (1826) CHRISTALLER (1933) HAIG (1927) WEBER (1929) LÖSCH (1939) HOOVER (1948) ISARD (1956) WINGO (1961) ALONSO (1964) LOWRY (1964)
Descriptive Theories of the City	BURGESS (1925) HOYT (1939) HARRIS-ULLMANN (1945)
Bibliographies & Reviews	VOORHES (1959) TRAFFIC RES. CORP. (1963) LEE (1973) MOORE et al. (1975) PUTNAM (1975) DICKEY (1976)
Land Use - Transportation	HANSEN (1959) GOLDBERG (1970 and 1972) BLUNDEN (1971) MUDGE (1974) DOWNING (1977) LOS (1975 and 1977) LOS (1979) STINO (1977) ECHENIQUE (1985)
Gaming Models	ENVIRONMETRICS (1971) FELDT (1972) FOUND-RICE (1977)

1.2.1 The Land-Use Models

The Land-Use Models have been employed since the late 1950's to forecast land-use changes as an input of the transportation planning process.

Starting with the transportation study of the Chicago metropolitan area, and further developing with the contribution of **Isard (1960)** and **Lowry (1964).** These models have been employed as tools for planning in some computer-based models, like EMPIRIC and DRAM in the late **1960's (see Voorhes, 1959; Traffic Research Corporation, 1963; Moore, 1975;** and **Dickey, 1976).**

Models deal with factors affecting general change in a region, including population and economic growth (or decline), location of residences, jobs, services and supply of transportation. But they present some important limits of applicability, because of:

- the long time period involved (up to 20 years into the future);
- the uncertainty associated with the input variables and their forecast;
- the existence of so many factors that can affect land-use development and so, the complexity and difficulty to foresee phenomena.

For these reasons, models have been criticized and reduced in importance in the planning process (see **Lee, 1973**).

Fundamentally, a model is a device that may describe, represent or present a facsimile or analogy of a situation, phenomenon, or system, using some form of mathematical function or quantitative technique **(Moore et al., 1975).** Models are usually "descriptive" for analysis and understanding of reality, and "simulative" of reality for forecasting and testing of alternative purposes.

In the Land-Use Models many "development factors" are considered to influence the change in the population and employment activities. These include "public service" supply, such as transportation; water and sewage; other public utilities (e.g., gas, electricity, telephone); educational and health services (schools and clinics); police and fire protection services. Transportation is one of the most important elements in almost all urban development models.

Other interesting types of urban models are the "gaming models" which provide opportunities for education, training, citizen participation and possibly research (see **Environmetrics, 1971**); some of them are specially conceived for Urban Transportation Planning purposes, and could be seen as operational planning tools **(Found-Rice, 1977).**

1.3 The Empirical Approach

Many studies and much research has been carried out on factors affecting the demand for travel, that is : generation, distribution, modal choice, and length of trips made in an area.

In relation to the use of public transportation, using statistical data, surveys, and comparing different areas, a variety of factors have been found to be determinant of the transit patronage level: firstly, physical planning and land use patterns; as well as other local characteristics, such as income, car ownership, level and quality of transit service, transit fares, perceived and real travel time, service traffic congestion, and parking availability **(CUTA, 1985).**

Basically two general relationships link together transit and land use:

1) Land-Use density and trips generated;
2) Land Use, transportation, and energy consumption.

During the 70's the publication of the Real Estate Corporation's report "The Costs of Sprawl" **(U.S. EPA, 1974)** activated a large debate about the energy-efficiency of different types of urbanization, declaring the high costs of suburban "sprawl" which comes with low residential densities and the use of automobiles. Comparing six alternative development scenarios for a new community, the study found that a planned community with a dense centre (19 dwelling units per net residential area) would consume 44 % less energy than a typical sprawled low density design (3.5 units per acre).

The better energy efficiency of the high-density land use is due to larger use of public transit (35 % of all trips made by persons living in high-rise apartments, compared to 5 % of all trips taken by residents of single family homes) **(MMT, 1980)**. Numerous works have demonstrated that the link between transit ridership and city size is directly proportional: the greater the city size, the greater the transit ridership. The most important book, however, which analyzes statistically and empirically the relation between Transportation and Land-Use Policy is the work of **Pushkarev** and **Zupan (1977)**.

They found that public transit use is primarily dependent on the size and density of the non-residential destinations of trips, i.e., the size and density of the Central Business District (CBD). Moreover, the number of trips made by transit rises with increases in net residential density, the closer a neighborhood is to the CBD, the higher the percentage of trips by public transit.

Nitkin (1979) has identified four land-use components or factors affecting travel behavior. These are:

- size (of population, employment, households);
- density (of nonresidential destination, and residential origin of trips);

- design (layout of streets, lots, building orientation, parking, accessibility to commercial sites and services);
- arrangement (land-use mix, employment/labour balance, urban structure, disposition and characteristics of centres, residential and employment areas along transit corridors, ...).

While the influence of land use and physical planning on transit ridership is well documented, the debate over the opposite relationship is controversial. The concern is over whether and how new transportation facilities can influence land use patterns.

"While there is increasing agreement that policymakers should consider the land-use consequences of transportation decisions, there is no consensus on the degree to which they should endeavour to shape development trends on the directions of development that they should consider desirable. In the short run, the direction of influence is predominantly from land use to travel. That is, trip-making patters, volumes, and modal distributions are largely a function of the geographic distribution of activities. Accessibility is a vital consideration as locational decisions are made. Thus, over time, transportation is a significant factor in shaping land use" **(Altshuler, 1979)**.

Nevertheless, starting in the 70's, a large interest developed over the impact of new transit facilities on land use and values - either looking for the possibility to use transportation investments as a lever for urban development (Impact Studies), or searching to avoid the negative impacts of transportation facilities on the environment (Environment Impact Assessment).

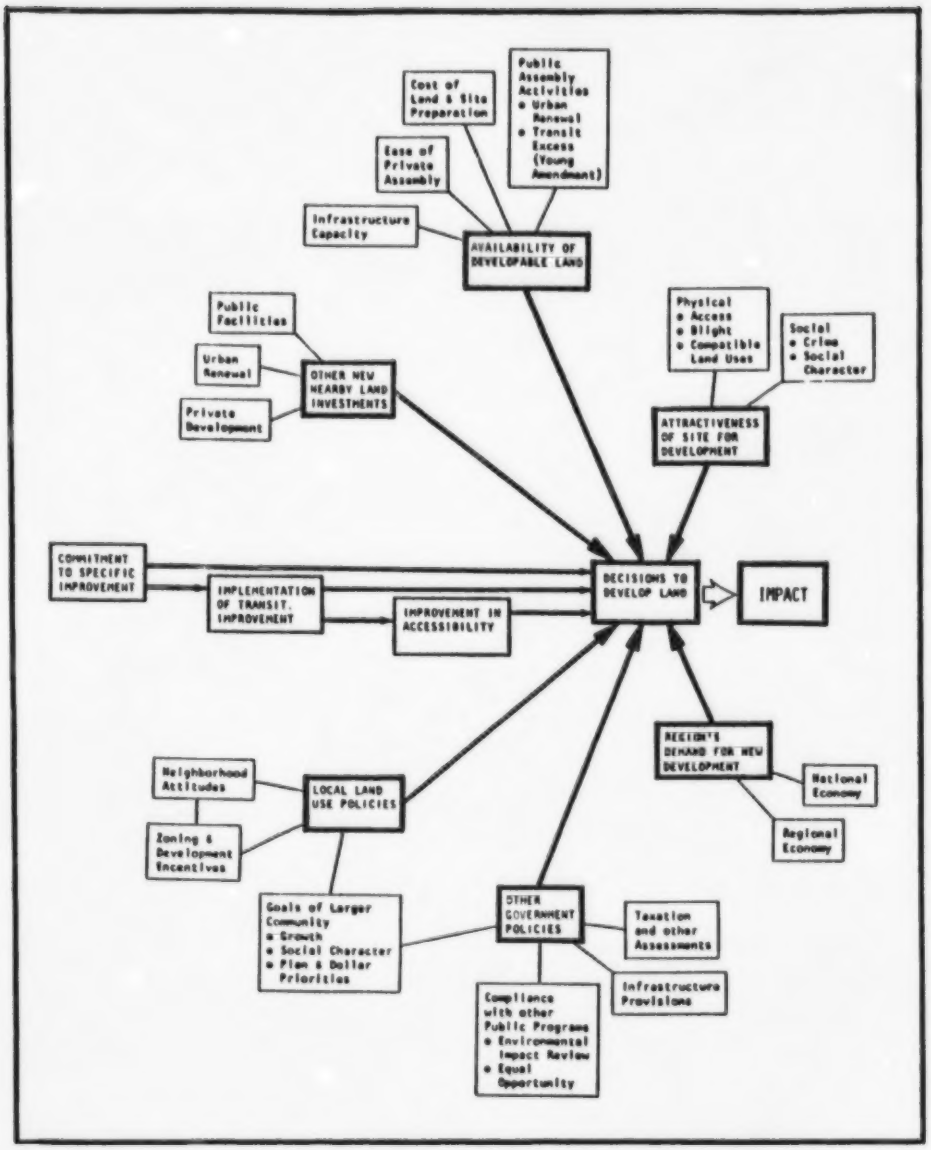

Figure 1: Factors influencing Land-Use Impact
(from Knight and Trygg, 1977)

2. CASE STUDIES OF IMPACT ANALYSIS

A large quantity of Impact Studies has been carried out in the last 15 years, though the analysis of the tranformations on land use after the opening of a new transit line, and the comparison of the situation in Philadelphia, San Francisco, Montreal, Toronto, Washington, Atlanta, and other cities.

Table 5

Empirical Studies - The Impact of Transit

Empirical and Statistical	U.S. EPA (1974d) PUSHKAREV-ZUPAN (1977) NITKIN (1979) MMT (1980) LAM-MERRAL (1982) CUTA (1985)
Impact of Transit Comparisons	WENDT (1968) HAMBURG (1970) SHELDON-BRANDWEIN (1973) DAVIES (1976) KNIGHT-TRYGG (1977) PARENTEAU (1977) U.S. DOT-OUR (1983) BOIVIN (1987)
Toronto	DEWEES (1973) RICE (1977) BOWER (1979) PILL (1979) WHEELER (1981) TTC (1983) PILL (1988)
Montreal	LEDOUX (1976) CAMUS (1977) CHAPLEAU-LAVIGUEUR-BAAS (1986) NOEL (1986)
Other	SPENGLER (1930) DOWNING (1973) AYER-HOCKING (1986)

2.1 The Land-Use Impact of Transit Systems

The report of **Knight** and **Trygg (1977)** is one of the most important studies on the impacts of rapid transit improvements on urban land use.

It analyzes the cases of Toronto, Montreal and San Francisco, among the modern realizations; and the improvements in Philadelphia (Lindenwold), Boston, Washington, Chicago, New York and Cleveland. Moreover it reports briefly on the European experience and the impacts of transit other than subways (commuter rail, LRT, busway). The approach is historical, descriptive and analytical, and is based on a review of the literature, site visits, interviews and data processing.

The historical analysis highlights the importance of technological innovation in transportation to shape the urban growth along transit lines. But other forces were also important, like the geographical restraints, the social and ethnic groupings, the previous existence of development and its value, the early land-use controls and taxation policies.

The situation in the past was very different from the current one. Today's transit improvements do not usually provide the kind of drastic improvements in overall accessibility as in the late 1800's. The automobile often provides a superior competitive alternative for many travelers, therefore, a transit improvement will not provide a land-use impact by itself if not accompanied with other complementary forces.

In the analysis of recent experiences it has been found that in many cases significant impacts on land use have occurred, especially near transit stations, but only with the contemporary presence of other complementary factors. These factors include: land availability, its ease of assembly, the social and physical characteristics of the area, the economic conditions, community support and public land-use policies.

Conversely, when these forces were absent or weak, few land-use impacts were found.

Toronto is the most important example of intensive development near the transit stations, either downtown or in the suburbs. In Montreal and San Francisco, on the contrary, the lack of demand for new development and the community opposition have been some of the causes of a lack of development in suburban areas. As such, development after transit improvements occurs only when supported by other favorable forces.

Firstly, the existence of a strong and effective demand for new office, retail and apartment development is important. Secondly, other controllable factors are important for generating land use impacts, as local land-use policies, other nearby investment, availability of developable land, attractiveness of the site for development. Public policy can steer the changing process by stimulating and controlling these many forces with adequate policies.

So transit improvement is not the only adequate way to generate impacts. Coordination of policies and joint development with private developers could be very efficient tools.

2.2 Case Studies of Impact Analysis

2.2.1 Toronto

Wheeler (1981) analyzes statistically the impact of the subway on land use in Toronto by comparing the change in population, employment, housing and property values in areas bordering the subway stations and in other areas.

The impact of the subway varies drastically from station to station indicating that the subway was a necessary, but not sufficient cause to explain the land-use transformations. The techniques used to attract development around subway lines were particularly important in the Toronto case. The design, location and spacing of stations enhanced the accessibility of the system.

The expropriation and land assembly along the routes and around the stations were the result of the close cooperation between the T.T.C. (Toronto Transit Commission), the City of Toronto and the Metro Board.

Lease of air rights above the stations and joint development were realized in cooperation with private industry and allowed an economic revenue for both the developers and the public Agency. Besides, enhancing the density around the stations allowed savings in residential land use. The availability of surplus subway properties permitted the planning of redevelopment areas: office, commercial, and mixed use in the suburbs.

Changes in zoning by-law and bonus provisions to permit high density development were allowed on a case by case basis, following these criteria:

- Redevelopment should be encouraged by detailed planning and by convenient assembling of land in strategic locations;
- The supply of high density development should be related to real demand, because zoning does not encourage but only permits development;
- Development should be permitted only in convenient locations, not merely because it is on the subway.

2.2.2 The Philadelphia-Lindenwold Line

At the beginning of the 1970's the realization of a commuter high speed line between Philadelphia and Lindenwold, along a developing axis originated a series of studies on the impact of the railway transit. The study of **Mudge (1972 and 1974)** about the Impact of Transportation Saving on Suburban Residential Property Values, prepared as a Ph.D. dissertation at the University of Pennsylvania, is a theoretical and empiric research about the effects of the Philadelphia-Lindenwold line.

The most important conclusions of the study were:

(a) The Lindenwold line has had a positive impact on nearby residential property values in suburban South Jersey.

(b) This impact does not seem to conform to the travel savings theory of transit impact as expected.

(c) In addition to spatial variation, the impact varies with socio-economic groups. It is more apparent in lower and middle class areas as compared with more expensive neighborhoods.

(d) There appears to have been very little anticipation of the Lindenwold line by the residential portion of the real estate market. But this market reacted and then adjusted very rapidly once operation commenced.

(e) Some evidence was found that at least a portion of the impact in the Lindenwold corridor is a transfer from nearby corridors.

2.2.3 San Francisco. The BART

The Bay Area Rapid Transit of San Francisco, opened in five stages, from September 1972 to September 1974; it was the first new urban rail system built in the United States in 50 years and marked the inversion of a trend shifting the interest from private automobile to public transit. The realization of the BART was accompanied with a series of impact studies comparing the before-after situation using control areas, and evaluating a "No-BART Alternative", for comparison purposes (see, HRB 111/1970).

Seven types of transportation impacts were defined to be investigated:

(a) traffic flows;

(b) travel behaviour;

(c) land use and urban development;

(d) regional economy;

(e) environment;

(f) social institutions and life styles;

(g) public policy. (see Table 6)

The findings of the BART impact studies showed that most effects were relatively small:

- Although BART induced more trip making (about 10 % of BART trips would probably not have been made without BART) it carried only 3 % of all trips generated in its greater service area.

- Land use and urban development were only marginally influenced by BART (there were not any great increases in prices and rents, neither residential nor activities relocation, nor increases in retail sales). High density residential development did not occur in BART station areas zoned for such uses.

Nevertheless, it has to be said that the BART has been conceived more as a suburban railroad than an urban subway/elevated system; besides, the impact studies were carried out during a short period of time after the opening (5 years); and finally, the BART met with some local opposition, without being accompanied with an agreement of public policies.

Table 6

Case Studies of Impact Analysis

San Francisco, BART	HRB Special Report 111 (1970) ZWERLING (1974) JONASH (1977) BLAYNEY-DORNBUSH (1979) BOOZ-ALLEN-HAMILTON (1979a) BOOZ-ALLEN-HAMILTON (1979b) GIVEN-DELEUW-CARTER (1979) McDONALD-GREEFE (1979) MINKUS (1979) PEAT-MARWICK-MITCHELL (1979) URBAN DYNAMICS ASS. (1979) US DOT-UMTA (1979)
Philadelphia-Lindenwold	BOYCE et al. (1972) GANNON-DEAR (1972) ALLEN-MUDGE (1974) MUDGE (1974)
Washington METRORAIL	LERMAN et al. (1978) DUNPHY-GRIFFYTHS (1981) DUNPHY (1982) MWCG (1983a) MWCG (1983b) CATER (1984)

2.2.4. METRORAIL, Washington

More recently a large program of impact analysis has been carried out to focus the changes in the Washington area before-and-after the opening of the 101-mile Metro system. **Lerman et al. (1978)** analyze the alterations of the spatial distribution of urban property values by employing a series of economic models and a survey of five separate transit stations.

Dunphy and **Griffiths (1981)** analyze the travel changes resulting from the first four years of operation of the transit system; while **Dunphy (1982)** studies the trends in housing, employment, and retail sales, before the system opened.

Caldwell (1983) takes into account the nonresidential construction activity in the Washington region before and after the opening, analyzing over 28,000 nonresidential permits authorized during 1972-1982. **Cater (1984)** compares changes in employment around subway stations to changes in the metropolitan area using 1976 to 1980 data.

The "Metrorail System" was planned during a period of rapid growth. Rapid transit and land-use planning were seen as tools for shaping growth. A special planning was undertaken around the system's stations to promote development, using zoning and other special regulations at the stations **(MWCG, 1983a)**.

A comparison of the impacts of the new transit systems of Washington, Atlanta and San Diego **(Donnelly, 1982)** resulted in a generalized increase in travel capacity, in accessibility, and in mobility along the transit axis. Significant impacts were also found in land use and economic development patterns, and some joint development sparked on the station areas.

But, by comparing the amount of public investments put in those rail systems, eventhough their economic impact has been significant, all the systems studied are so new that the full results will require later appraisal.

2.2.5 MARTA - Atlanta

Another interesting experience of a successful effort to fully integrate transportation planning and urban development/redevelopment is the MARTA system in Atlanta, Georgia **(Davis et al., 1985).**

Development along the transit route is not automatic, but it fostered through supportive zoning, special incentives, and strong markets; Atlanta has pioneered this kind of comprehensive city planning, with zoning and policies designed to promote growth and mixed-use development in station areas, with public-private conventure in joint development.

Mechanisms for stimulating public-private conventure are: tax increment financing, special benefit, assessments, dedicated property taxes on station areas, and zoning controls designed to shift some financial burden to the private sector.

Growth management strategies proved most successful are: (1) development agreements between the actors; (2) early developer investment in planning; (3) leasing and/or selling air rights; (4) public underwriting of initial feasibility studies; (5) land banking.

2.3 The Joint Development Practice

Experiences in Atlanta, Toronto **(TTC, 1983; Rice, 1977; Pill, 1988),** Los Angeles **(US DOT-OST, 1983; Sharpe, 1977)** Washington, Baltimore **(Keefer, 1984))** and other cities, suggest a central topic to steer the land-use changes, stimulate development with transit investments, and activate the cooperation between public and private: the value capture or joint development practice.

With the adoption of well-addressed public policies, together with the existence of basic conditions (positive economic trend, expanding demand, availability of land, money, etc.) the objective can successfully be reached. But Transit Agencies must take an active role in joint development; the developer should be involved early in the planning of the local project; and basically, the local government and transit agency must establish clear supportive policies.

One of the earliest studies on the value capture and joint development applications, which enhances and captures financial and/or community design benefits related to transit system implementation, has been the work of **Sharpe (1977)**.

Starting with the comparison of the experiences of Chicago, Louisville, and Los Angeles, he presents a recognition of the diversity of legal, political, economic and physical problems public policy can meet.

Very useful moreover, have been the publications of the Urban Land Institute, **ULI (1979, 1980, 1982)**, a series of practical handbooks which review cases of realizations of joint development linked with transit improvements, downtown revitalization, development of office growth, etc., analyzing the techniques, the problems, the issues and the practice of joint development and public/private cooperation. **Keefer (1984)** analyzes the costs and benefits for public Transit Authorities engaged in joint development in connection with the construction, reconstruction or general improvement of rapid transit stations, or bus and/or intermodal teminals. He compares three different policy approaches: (1) the Washington approach, which is presently the most ambitious and successful in the U.S.A.; (2) the Market Center Development

Corporation of Baltimore (MCDC), which is also ambitious and successful, represents a strikingly different approach and philosophy; and (3) the Los Angeles approach. The report of the National Cooperative Transit Research and Development Program **(NCTRDP 12/1985)** reviews methods, techniques and strategies of public policy in this field.

Table 7

Joint Development

CHESLOW-OLSSON (1975)
SHARPE (1977)
LACEY et al. (1979)
PAASWELL et al. (1979)
US DOT (1979)
ULI-GLADSTONE (1979)
ULI-BASILE (1980)
ULI-BLACK (1982)
US CONFERENCE OF MAYORS (1980)
US DOT-OST (1983)
KEEFER (1984)
DAVIS et al. (1985)
NCTRDP, Report 12 (1985)

3. TRANSPORTATION SYSTEM IMPACTS

3.1 The Environmental Impact Assessment

After the promulgation of the NEPA (National Environmental Policy Act) in 1969, the E.I.A., Environmental Impact Assessment, of the transportation projects has begun a usual practice. Nevertheless, the first attention in the impact analysis has been for the protection of the existing physical, natural, and social environment. In fact, a general checklist provided by the U.S. DOT-FHWA (1974) shows the impacts to be considered in highway project analysis, as:

a) Natural resources

b) Relocation of displaced inhabitants

c) Social impact for the disadvantaged

d) Air quality

e) Noise

f) Wetlands

g) Stream modifications

h) Flood hazards

i) Construction effects

j) Historic and cultural sites

k) Parks

Table 8

Environmental Impact Assessment

Handbooks and General	WEINER (1972) BERRY (1974) ROSEN (1976) CHEREMISINOFF-MORRESI (1977) MTC (1977) U.S.-DOT (1979) RAU-WOOTEN (1980) BILLHEIMER-TREXELER (1980)
Bibliographies	U.S.-EPA (1975) WOLF (1979)
Physical	U.S.-DOT (1972) U.S. DOT-FHWA (1974c) U.S. EPA (1974b) U.S. EPA (1974c)
Social Economic, Environmental	HRR/356 (1971) U.S. EPA (1974a) U.S. EPA (1976) NCHRP/40 (1977) U.S. DOT (1978)
Esthetics and Visual Impacts	LYNCH (1960) APPLEYARD-LYNCH-MYER (1964) APPLEYARD-LYNCH (1967) SILVER-BELL (1975) HEDER (1980)
Environmental Impact Statement	U.S. DOT-UMTA (1982) U.S. DOT-UMTA (1983) U.S. DOT-UMTA (1984) MORTON (1985) PATERSON (1985)

The practice of E.I.A., addressed to the protection of the existing environment has found it difficult in dealing with secondary or indirect impacts which develop in long-term periods, like Land-Use impacts. Also, determining the significance and weight of the impacts is far from easy; however, the E.I.A. has developed the important practice of citizen participation in the decisional process and changed the practice of planning.

The most important impacts considered in the E.I.A. practice for transportation projects during the 1970's were:

(1) Energy consumption, as a consequence of the price of oil increases;

(2) Air, water pollution, and noise, following the growing interest of public opinion for the protection of the physical environment;

(3) Relocation of displaced inhabitants, especially the poor, the elderly and the disadvantaged;

(4) Visual impacts, or aesthetic and intrusive impacts of the new highways and other infrastructures (see Table 8);

(5) Effects of transportation improvements on retail sales and land values, over all those due to highways (see table 9).

The attention to the aesthetic and visual impacts of transportation facilities, especially from the point of view of the driver, has developed from the work of **Lynch (1960)**, **Appleyard et al. (1964)** and **Appleyard and Lynch (1967)**, concerning the "View from the Road" and the studies about the perception of "The Image of the City". A set of criteria for the evaluation of the Visual Impact has been developed by Lynch, regarding:

(a) Sensations of comfort for the beholder;

(b) Alternating of diversity of sensation;

(c) Perception of the identity of places, as recognizable, memorable, vivid;

(d) Possibility of relating places to one another, understanding their pattern in time and space;

(e) Perception of the environment as meaningful;

(f) The environment should encourage attention and exploration, stimulating the beholder.

These principles have improved the evaluation process of transportation projects and entered in the practice of planning.

3.2 The Impacts of Highways

The studies on the impact of transportation investments on land development started in the late 1950's with the research of **Garrison et al. (1959)** in the Washington State, and **Adkins (1959)** in Texas, on the social and economic effects of highways. The work of Garrison, both theoretical and empirical, could be seen as the first manual of the Environmental Impact Assessment of transportation infrastructures. In the 1960's great attention was payed to the use of highways as a developing factor for countries and regions (see **Wilson et al., 1966**), but, subsequently, more attention was payed to effects of highways on local retail sales, land value and economic and social impacts (**NCHRP 18, 1965; Wendt, 1968; NCHRP 122, 1971; Van der Tak, 1971**; etc.).

Research showed many variances in the impacts. Particularly, the largest towns almost always appeared to gain significantly, while the smaller ones lost equivalently. Moreover, if increased land values were found near the freeway facility, they rapidly declined with distance from the freeway.

In the 1970's the attention was shifted from the impact of highways to that of public transit facilities as a tool of land-use improvements. The work of **Billheimer** and **Trexler (1980)** is a very useful handbook of Environmental Impact Assessment specifically designed

for Transportation facilities. Some Environmental Impact Statement Studies (E.I.S.) on the impact of subway facilities have been carried out in Miami, Los Angeles and New York (U.S. DOT-UMTA, 1982, 1983, 1984).

The studies on the Environmental Impact Assessment of the GO Transit and the Subway in Toronto are equally interesting, done for the Ontario Ministry of Transportation (Morton, 1985; Paterson, 1985).

Table 9
Effects of Highways

ADKINS (1959)
GARRISON et al. (1959)
JACKSON (1963)
ASHLEY-BERNARD (1965)
NCHRP, Report 18 (1965)
WILSON ET AL. (1966)
WENDT (1968)
NCHRP, Report 122 (1971)
VAN DER TAK (1971)
U.S. DOT-FHWA (1972)
HARRIS (1974)
U.S. DOT-FHWA (1974)
U.S. DOT-FHWA (1976)
NCHRP, Report 193 (1978)
U.S. DOT (1980)
QUEBEC, MIN. TR. (1982)
MIGNERON (1982)

3.3 The Urban Design and the Transportation Technology

One of the aspects of the relation between transportation and land-use system is the design of the components and the planning of the whole system configurating the transport network together with the other elements of the urban structure.

Starting with the publication of the Buchanan Report, about the consequences of the introduction of traffic in existing cities **(Buchanan, 1963)** an interesting discussion originated on Urban and Transportation Planning, about the concepts of 'travel corridor' emphasizing movement efficiency, and about the 'environmental rooms' emphasizing living conditions.

The subsequent research of **Alexander (1966)** about the 'stratification' and overlaying of the urban functions in the historic city, criticizing the separation and the hierarchy adopted in the practice of planning, set off the discussion among the architects. An example of this new interest is the work of **Anderson (1978)** about the role of the streets in the urban form.

The debate about "Homes, Towns and Traffic" **(Tetlow** and **Goss, 1966)** had its roots in the theory of the Neighborhood Unit developed by Perry in America **(Perry, 1929; Isaac, 1948)** and the idea of "residential cluster" developed in the Garden city experience by Howard, Unwin and, after the Second World War, by the experience of the British New Towns.

The basic concepts of the "Strategic Land-Use-Transportation Planning" are those of hierarchy, either of activities or of transport routes, and that of Environmental Area **(Hutchinson, 1974).**

The various activity concentrations are hierarchically organized at three different levels: the community center level, the district level, and the regional center level. The transport system put in relation the activity center in two different ways: one emphasizing the movement efficiency (through route), the other emphasizing the land access (access route). Movements are channelled along the boundaries of the environmental area or arterials. Direct access is provided by collectors and local roads.

At the urban level, three main types of urban structures may be identified and these are the centripetal, the grid, and the linear structure. The first one is rigid in relating the activity centres and could be efficient for transportation only if most of the travel takes place on public transport. The second one is more efficient for the transportation network but it presents some problems for the location of the community and district centres. The third one, conceived as a transport related urban structure, has instead a speed of movement that is too poor along the corridor and a width that is too narrow.

These concepts of the characteristics of urban structure are more theoretical than empirical and they are not easily related to the existing urbanized areas. Nevertheless, they now make up the background of urban transportation planning. They found in the past practical application in the experience of the British New Towns **(Tetlow-Goss, 1966; Potter, 1984)**, in some new planned district or city expansion, or new built capital, like in Stockholm, Sweden, South Hampshire, England, or Canberra, Australia (see **Hutchinson, 1974; Buchanan, 1975; Alpert-Lesley, 1979**).

During the 1960's, there was a considerable interest in the new transportation technologies and their relation to the urban form. The work of **Richards (1966)** and the special issue of the journal of the Franklin Institute about "the New Transportation systems" **(Warburton, 1968)** marked a stage on the contemporary debate.

Right through the 1970's the research on the urban form of transportation-related-city continued with designs and plans (e.g. **Walbridge, 1977**). But more recently, with the shortening of public investments in transportation, the decreasing of physical urban growth, and the end of the unlimited trust in technological progress, the interest has been shifted to the reusing of existing transportation

facilities, the urban redevelopment of urbanized areas, and a greater attention was given to the problem of efficiency and management of existing resources.

Table 10

Characteristics of Urban Structure

The Neighborhood Theory	PERRY (1929) ISAACS (1948)
The Urban Structure	BUCHANAN (1963) ALEXANDER (1966) TETLOW-GOSS (1966) HUTCHINSON (1974) BUCHANAN (1975) ANDERSON (1978) ALPERT-LESLEY (1979) APPLEYARD (1981) POTTER (1984)
The Transportation Technology	RICHARDS (1966) WARBURTON (1968) WALBRIDGE (1977)

INITIATIVE	IMPACT ON TRANSIT: RIDERSHIP	OPERATING COST	QUALITY SERVICE
DENSITY			
• DENSITY BONUSES AT DESIGNATED LOCATIONS	●	●	
• MARKETING VACANT BUILDINGS AND LAND PARCELS (SELL OR LEASE)	●		
• REZONING TO PERMIT OVERALL HIGHER POPULATION, EMPLOYMENT DENSITIES	●	●	●
• JOINT PUBLIC - PRIVATE INVESTMENT IN REDEVELOPMENT PROJECTS			●
DESIGN			
• COMPREHENSIVE TRANSPORTATION / LAND USE / SOCIAL PLAN	●	●	●
• TRANSIT PRIORITIES (EXCLUSIVE LANES, SIGNAL PRIORITY, CONTRA FLOW TRAFFIC LANES)	●	●	●
• CO-ORDINATE STATION DESIGN - COMMERCIAL / RESIDENTIAL / OFFICE BUILDING ACCESS	●		●
• COMPLETE THROUGHFARES IN ROAD NETWORK		●	●
• WIDEN STREET NEAR TRANSIT STATION (LOADING, UNLOADING)		●	
SIZE			
• PUBLICIZE GASOLINE PRICES AND COMPARATIVE COST OF OPERATING AUTO VS. TRANSIT	●		
• PROPERTY TAX CREDIT FOR REGULAR TRANSIT USE	●		
• HIGHER VEHICLE REGISTRATION FEES	●		
• PARKING POLICY (INCREASE FEES, SELECTIVE LOT LOCATIONS, PROHIBITION OF ON-STREET PARKING, LOWER SPACE ALLOTMENTS PER UNIT)	●	●	
ARRANGEMENT			
• INCENTIVES FOR EMPLOYERS / EMPLOYEES WHO HIRE / WORK LOCALLY (MORTGAGE INTEREST / RENT DEDUCTABILITY / INCOME TAX REBATE / PARKING FEES)		●	
• PROMOTE APPROPRIATE MIXES OF HOUSING COMPATIBLE WITH EMPLOYMENT, RECREATIONAL LAND USES		●	
• FLEXIBLE WORK AND TRANSIT SCHEDULING		●	●
• RATION GASOLINE	●		

Figure 2: Initiatives to Promote Transit Use
(from Nitkin, 1979)

4. CRITICAL REVIEWS OF THE SUBJECT

Some authors have made a review of the literature about the relationship between Transportation and Land Use or Land Values. In addition to the authors of the basic textbooks in Transportation Planning **(Meyer-Miller, 1984; Dickey, 1983; Manheim, 1979;** etc., see Table 1), there are a few other authors who have compared the existing literature, and expressed some conclusions about the topic:

- **Rice (1975);**
- **Gomez Ibanez (1975);**
- **Falcke-Dornbush (1982);**
- **Gomez Ibanez (1985).**

While **Rice (1975)** explains the possibilities of public policy to guide the land-use changes, Gomez Ibanez disagrees, representing the opposite point-of-view **(Gomez Ibanez, 1985).** All the papers also include a review of different methodologies mostly used in the analysis and planning (see, particularly, **Falcke-Dornbush (1982)).**

4.1 A positive point-of-view

Ron Rice, in his "Transportation Impacts on Urban Land Use: Some Policy Perspectives" **(Rice, 1975a)** presents **a review of the relevant literature providing a general** framework to the discussion, addressing the analysis to the perspectives of controlling these phenomena with public policies.

There is a mutual influence between the transportation system and the distribution of the social and economic activities within an urban area; so, improvements in transportation supply could be translated into changes in land-use activity levels and location. Besides, there is another kind of impact linked to the physical presence of the transportation facility itself which is typically negative: neighbourhood disruption, aesthetic considerations, environmental impacts (noise, vibration, air and water pollution).

So there are two main types of land-use impacts:

a) **local impact** (direct, short-term, physical, within an immediate corridor);

b) **urban development impact** (indirect, area-wide, long-term, affecting the magnitude and location of land-use activities).

Taking into account the total benefits of transportation investments, decision makers should not consider only the internal efficiency, but, because of the transferred user benefits activated by the investments, they should evaluate it in terms of equity or distributional concerns.

In his review of the literature, Rice singles out six groups of studies approaching the subject from different points of view: 1. Modal Operating Efficiency; 2. Accessibility; 3. Impact Analysis; 4. Urban Land Rent Theory; 5. Systems Modelling; 6. Policy Modelling.

4.1.1 Modal operating efficiency

Studies about the statistical and empirical relationship between the modal choice of transportation and land use. They employ socio-economic indicators, like car ownership, residential density, etc. For instance, **Meyer, Kain** and **Wohl (1965)** find that the automobile provides the most efficient level of service for corridor volume of 5,000-10,000 persons per hour. Publications like these are numerous but their main limit is that you cannot establish a standard from the average characteristics observed in some urban areas.

4.1.2 Accessibility

Studies evaluate the percentage of population having access to the job occasions in an area in a limited amount of time (see **Sherman et al., 1974**). They are useful in order to compare the effectiveness of different alternative transportation systems, but they are insensitive to local or subsystem variations policy.

4.1.3 Impact Analysis

There has been a lot of research done on the impacts of the transportation facilities: particularly the impact of highways during the 60's and the impact of rapid transit during the 70's (for example: **U.S. DOT-FHWA (1972); Boyce et al. (1972); Dewees (1973)**). An important discussion has concerned the methodology of the analysis. The "Before-and-After Study" and the "Control Area" are the most used methods to compare transportation corridors with similar, non-improved corridors **(HRR, Special Report 111, 1970; MTC, 1974)**. Still, it is very difficult to check experimentally and to forecast the transformations before and after the improvement. Nevertheless, it seems that transportation improvements are reflected on land prices, and that a percentage of the impact is due to a transfer of property values from unimproved corridors **(Boyce et al., 1972; Dewees, 1973)**. Impact varies with socio-economic characteristics and with the kind of transportation facility, but it cannot be deduced from previous examples; every situation is a case-study and needs a special survey.

4.1.4 Urban Land Rent Theory

The theory of "differential rent" allows us to understand the changes of land value in terms of changes of accessibility which can increase the production possibilities of land. There are consumer-oriented models **(Wingo, 1961; Alonso, 1964)**, and supply oriented models **(Averous-Lee, 1973; Capozza, 1973)**. Moreover there are empirical studies that adopt multiple linear regression analysis techniques. It is difficult to carry out these studies, because of:

- lack of suitable data;
- difficulty in isolating the site value component from the remainder of the total property price;
- finally, there is often a lack of empirical evidence of analyzed phenomena.

4.1.5 System Modelling

The analytical models, which were very important in the 60's and 70's, have shifted the attention from transportation forecasting given the land-use patterns to the land-use consequences of different travel demand **(Lord Miron, 1971; Rice, 1975b)**. There are a lot of studies dealing with the urban system modelling. Although they are controversial, they have achieved some general conclusions:

- the best balance of the location of job services and residences can improve the efficiency of the urban system;
- the roadway system is more efficient than the transit network in terms of flexibility and adaptability, however, the efficiency of the system is better if a mixed-mode alternative is adopted (roads and transit);
- the joint planning of the transportation and land-use system may result in an increase of land-use development, although it is difficult to control it in space and time;
- there are conflicting conclusions about the best relationship between alternative land-use configurations (high density, urban sprawl, centrally-oriented city) and the transportation efficiency; it seems, however, that the multi-centered city has the best requirements;
- the majority of the transportation land-use models are static, and they hardly relate with the dynamic process.

4.1.6 Policy Modelling

Some models are recently dealing with the evaluation of alternative Land-Use Transportation policies permitting to compare dynamically the effect of different transportation investments and the action of other exogeneous factors **(Metropolitan Toronto Transportation Plan Review, 1974-1975)**.

4.1.7 Final Remarks

At the end of his review, Rice gives recommendations about the role of public policy as a guide of transformation processes. It is difficult to control the land-use impacts of transportation through public policy, because of the overlapping and sharing of responsibility

among different authorities (local, provincial, national, for transportation, for land-use decisions...); and because it is hard to understand the indirect impact of policies.

Nevertheless, there is a wide range of possibilities of intervention, to build a public policy, operating in the different field of:

- land-use control (zoning, planning, ...);
- fiscal policies (finance, taxes, ...);
- administrative control (pricing, licencing, ...);
- direct investments in transportation (facilities, rights-of-way, supply, ...).

Public policy should be addressed to promote actions linking transportation to land-use objectives, for instance, by:

- developing multi-centered urban forms;
- coordinating a multimodal transportation system;
- developing a dynamic, strategic, staggered planning;
- coordinating new investments with management already in existence.

Public policy should be addressed to guarantee allocation efficiency (equity of opportunities for all socio-economic population groups). At the aggregate scale, the physical performance of the proposed projects should be evaluated in relation to land-use densities, modal accessibility indices, work opportunity distributions, and other land-use standards. Locally, the Impact Analysis should point out the land-use, social and environmental effects of transportation investments, allowing opportunities for citizen participation to the decision process.

Table 11

Theoretical and Empirical Research
(Gomez Ibanez, 1985)

Residential Location Decisions:	HAIG (1927) WINGO (1961) ALONSO (1964) MUTH (1969) GETZ (1975)
Location Choices of Business:	WEBER (1909) HOOVER (1948) ISARD (1965) MOSES-WILLIAMSON (1967)
Central Place Models:	CHRISTALLER (1933) LöSCH (1939) GARRISON et al. (1959) BERRY (1967)
Location choices of Population-Service Industries:	LOWRY (1964) BERRY (1967) FORBES (1972)
Statistical Studies:	BOYCE et al. (1972) HARRISON (1976) KNIGHT-TRYGG (1977) BLAYNEY-DORNBUSH (1979)
Simulation Models:	LOWRY (1964) BRAND-BARBER-JACOBS (1967) GOLDNER (1971) PUTNAM (1973 and 1975)

4.2 A Negative Point-of-View

On the contrary, **Gomez Ibanez (1975 and 1985)** strongly disagrees with the possibility of using transportation policy as a tool for shaping metropolitan development. His thesis is that transportation policy cannot control broad patterns of urban land use, like the decline of central cities and the suburbanization and "sprawl" phenomena.

He points out three factors:

1) Urban land-use patterns are extremely difficult to change.
2) Impacts observed in the past of the development possibilities of current transportation policies are misleading.
3) Neither theoretical nor empirical research demonstrates this possibility.

4.2.1 Difficulty of changes

For many reasons it is unlikely that public policy in transportation can substantially and rapidly alter land use because:

- costs of moving structure to new sites are extremely high;
- buildings are extremely durable (more than 50 years);
- other factors apart from transportation establish the character of an area and its attractiveness (building types, social status, reputation, ...);
- transportation changes are only one of the many factors that influence residential location choices (e.g. income, quality of the environment, ...);
- business location decisions are also influenced by other non- transportation factors (like wage rates, production and communication technologies, ...);
- moreover, a lot of industrial production and services are high-income-added, and light weight, with a less incidence of the transportation costs.

4.2.2 The past experiences

In the past, transportation changes (from horse-drawn car, to street car, to automobile, to truck) have had an enormous impact in travel speed and costs, affecting land use and fostering suburbanization; but, at present time, the situation is different, because:

- the transportation changes and policies today have a smaller effect on speeds and costs;
- the new automobiles are so versatile and adaptable that they are not affected by higher gasoline prices or severe requirements for energy savings and environment protection;
- new transit lines cannot dramatically improve the accessibility of all the metropolitan population but only along the corridors;
- the reduction of time and cost of trips allowed by a transit system is limited compared with the efficiency and flexibility of a roadway system, especially during non-rush-hour;
- the transportation changes, also in the past, have not been the only factors responsible for suburbanization and location choice.

4.2.3 The theoretical and empirical research

In reviewing the literature, Gomez Ibanez examines the Location Theory, the Statistical Studies, and the Simulation Models (see Table 11).

The ability to understand the current situation and to predict future changes is very limited in theoretical models. The classic location theory connects the location choice of residences to the distance from the city centre and to the cost of land; nevertheless, with the increase of the income level, a lot of people want to use income gains to consume better housing services, overcoming the increased transport costs **(Muth, 1969; Alonso, 1964)**. Also, with the reduction of commuting costs, the savings could be transformed in increase of land rents, without affecting the location decision **(Getz, 1975)**. The same complexity is in the workplace location decision. There are a lot of statistical and empirical studies on the impacts of transportation facilities on land use using different methods of analysis, but, too often, these studies fail to control the influence of non-transportation factors (economic, social, political, ...) in evaluating the impacts.

Also, for the empirically calibrated simulation models, it is difficult to predict exactly the future land-use changes relying on the observed past trends: in the future they could be very different from the changes in the past. Finally, various incentives affected by a transportation change can produce different, alternative or conflicting

impacts on land use, and so, they could counterbalance each other; in this way, they are very hard to predict and control.

4.2.4 Final Remarks

In conlusion, it is difficult, at the present time, to evaluate and to isolate, among many factors, the land-use impacts of a transportation change. Actually, a transportation policy should require a lot of public investments and should condition the present system and the future perspectives to really influence the land-use patterns. On the other hand transportation policy serves other important objectives, like providing equal accessibility, reduce pollution or make energy savings. Other means, like zoning controls or housing policy, may be more effective to control land-use patterns.

4.3 The Methodologies

A report prepared in 1982 by Caj O. Falcke, of Dornbusch & Co., for the U.S. Department of Transportation deals with "the Methodologies for Assessing the Impacts of Major Transportation Facilities on Land User and Land Prices" **(Falcke-Dornbusch, 1982)**. It is based on a review of some 400 studies, journal articles, and papers done since 1960, and on some in-depth interviews of selected planners who have had experience with methods of assessing transportation impacts.

4.3.1 The Research

The attention to the transportation impacts has developed from the 1950's, revealing the complex system of interacting forces involved. At the beginning it was based on the use of large-scale models, the use of computers, and the theoretical work of **Isard, Alonso, Kain, Lowry,** etc. Later on, interest has shifted from the regional (and interregional) scale to the micro-scale analysis focusing on areas immediately around facilities, such as proposed rapid transit stations. Research has become increasingly interested in pragmatic methods for linking public and private sector activities in land development (joint development) and in mobilizing a variety of public sector tools (e.g. zoning development initiatives, transit station site selection, land acquisition and resale, location of public agency facilities, joint site development and

design) to maximize the desired focusing of development. At present, because of the coexistence of many economic, social and political actors in a region, and because the spatial layout of urban areas and their transportation facilities differ so much from one era to another and from one place to another, most empirical studies have chosen to focus on one transportation system in one place, at one time, and decided not to worry about general applicability of the results. This is a limit for the research.

4.3.2 The Studies

Among the different transportation modes, highways have been studied the most. Other modes, such as light rail, people movers, small vehicle transit system, are beginning to attract attention; as well as, Land-Use effects have been studied more frequently than Land-Price impacts. The literature is also dominated by studies on the effects of the physical investment in transportation facilities (a highway, a transit line, a bridge, an airport, ...). Less attention has been paid to the impact of policies, the economic characteristics and the quality aspects. In general, most of the studies have been undertaken to solve a specific problem, to forecast or assess impacts of a particular project or a given set of alternative policies, so, the bulk of the literature is modal-and-location specific; little research exists that explores the broad conceptual linkage between transportation, economic development, and the socio-political environment.

4.3.3 The Methods

The main analytical categories in which the studies can be grouped for their application, are:

- **descriptive,** without any specific aim;
- **exploratory,** explicitly undertaken to examine underlying causes or other factors;
- **ex post assessment** studies, comparing the before-and-after situation, often utilizing the econometric analysis, especially regression models, or controls with 'comparable' unaffected areas;
- **evaluation studies,** considering the impact of several alternative solutions on a specific transportation problem;

- **teaching research**, aimed at the advancement of the research "per se" rather than to solve a specific problem;
- **influence policy** studies, aimed at influencing a transportation policy or a decision process.

The methods can also be grouped into two categories:

the truly **quantitative techniques** (from no. 7 to 13) and

the more **qualitative methods** (from no. 1 to 6).

The qualitative methods are:

(1) **Literature Surveys, Case Studies**
(2) **Key Informants, Appraisals**
(3) **Delphi Technique**
(4) **Analyst's Own Judgement**
(5) **Land-Use Surveys, Mapping**
(6) **Control Areas, Tabulations**

The quantitative techniques are:

(7) **Input/Output Analysis**
(8) **Mathematical Programming**
(9) **Urban (Simulation) Models**
(10) **Theoretical (Micro-Economic) Analysis**
(11) **Econometric and Statistical Techniques**
(12) **Factor Analysis**
(13) **Dynamic Simulation Models**

4.3.4 Comparison of the Methods

The **Literature Survey**, and **Case Studies** method is an attempt to "learn from the experience of others" used in the design phase of studies. It is cheap and effective, but there are too many variables that differ from one place to another and, over all, "the impact is determined by both the transportation system and the existing complex of cultural interrelationships associated with transportation demand"; and they are both 'local specific'.

Key Informants or **Appraisers** are consultants with professional or academic knowledge on the subject in question who employ a great deal of subjectivity and professional experience in the assessment.

It is a valuable method when it comes to individual pieces of land. Its best use is in study design, in formulating and corroborating hypotheses, and interpreting empirical results. But results of a particular appraisal are not transferable.

The **Delphi Technique** is a practice introduced in the late 60's; it is an appraisal made by a panel of experts who can modify their replies after having studied everyone's initial comments; they should achieve a general consensus.

The **Analyst's Own Judgement** is a quick and cheap method, but it can be as good or as bad as the analyst himself.

Surveys and **Mapping** attempt to portray or document changes that have occurred in land-use and travel patterns. Mapping is more mechanistic. Surveys can also probe for the reasons for the changes.

The **Control Area** is compared with the 'Impact area' by means of arithmetic averages or median values for some selected characteristics. They are assumed to be similar to each other in all relevant aspects but the presence of the transportation system. The problems of this method concern the question of the true comparability and the existence of the simultaneous effects of other factors; moreover, the assumption that transportation impacts decrease with distance is difficult to prove with selected control areas. In fact, it is well known that the way a region is divided into subregions affects the results of a spatial analysis. Techniques used to detect the impact of different factors are: cumbersome 3 or 4-way tabulations, analysis of variance or covariance, regression analysis.

The **Input/Output Analysis** shows the effect an investment in the transport sector has on other sectors of an economic system. Results of the analysis will not be spatially disaggregated.

The **Mathematical programming** is difficult to use in linear form and with the specification of a valid objective function: activities do not locate only to reach the objective of minimizing travel time and cost, therefore, it is difficult to weigh a trade-off parameter that expresses the decision maker's value system.

The **Urban Simulation Models** are best used in the ex-ante impact assessment and to simulate the effect of alternative transportation configurations. Although the models are empirically calibrated, their capability of replicating past behaviour is no guarantee that they will be capable of predicting future events because of the long term of predictions, and because of the lack of linkages to non-transportation variables. Other weaknesses of most models are that they are strictly descriptive, static (developing in stages from a base year to an equilibrium), and demand-oriented; they take either land use or transportation as a given; they are data-intensive, and useful only for trained users.

The **Theoretical Analysis** is mostly based on the macroeconomic theory. Results are not readily transferable to practical applications.

The **Statistical Analysis (Econometric)** uses regression techniques, analysis of variance, covariance, analysis of the correlation, as tools. It has been largely employed by analysts, with the use of large masses of data, with a lot of variables, that should allow the analysis of the interaction between phenomena, including the assessment of secondary and tertiary effects; but the resulting equation could be highly influenced by random elements in the data, and there is no theoretical concept to alert the analyst's suspicions. However these techniques have resulted very useful in ex post assessments of the impacts and in the testing of theories and hypotheses, although the transferability of the results is not always good.

The **Factor Analysis** and the **Dynamic Analysis** have not been used extensively thus far in land-use transportation studies.

4.3.5 Final Remarks

In conclusion, there is a great deal of descriptive analyses and work on models capable of simulating and reproducing historical data; but very few of these results are transferable; very little is known about the underlying causes and processes. Very few models have accounted for the conditions of the economic, social and political environment in which the impacts occur. Instead, the main interest of the analysis, from a planning point of view, is to find out not only what happened, but how you can control or manage what is likely to happen. "A planner is an activist, not an observer". An important conclusive remark of the research is that "A transportation improvement by itself does not amount to much without supporting developments and policies".

5. CONCLUSION

The existence of a relationship between transportation and land-use changes has been proven either historically, theoretically, or empirically; but, so far, it is still difficult to use transportation investments as a tool for steering land-use changes, or predict exactly the intensity and direction of changes. However, a lot of experience exists today that allows public policy to improve these abilities.

The main criticism to the utility of the **historical studies** in understanding the present relationship is that changes in the past are misleading the present and, over all, future effects of transportation investments, because land-use patterns are difficult to change, and because the impact of new transportation technologies in the past was larger in increasing accessibility than today.

The **theoretical approach** was very important in the 1950's and 1960's with the use of the first computers and large-scale models, but later on, it decreased due to their specific limits. Firstly, the difficulty lies in the many overlapping factors that operate in reality. Secondly, these factors are 'locally specified' and vary from place to place. Thirdly, the existence of many non-transportation factors. Today this approach has been developed only by a few people (particularly by **Steve Putnam**, at Pennsylvania University).

The **Statistical approach** links together characteristics and intensity of land use to that of the transportation system looking for effective rules of the relationship (e.g. relationships between density, land use, car ownership, etc., and ridership, or energy consumption; see **Pushkarev** and **Zupan, 1977**). However, you cannot generalize from statistical studies, and they do not take into account the impact of local policies.

On the contrary, great guidance in organizing policy and planning can come from the comparison of real **case studies**, results of **impact studies**, and the **Environmental Impact Assessment** practice.

The evaluation criteria that have guided the transportation policy have shifted during the last decades from the concept of engineering efficiency to that of economic efficacy, to social equity, and to paying attention to environmental and energy issues.

From a planning point of view, the techniques of analysis and the methods of control of land-use/transportation phenomena are very important.

The main techniques used for the analysis of phenomena and forecasting are: the **Comparisons** (case studies, control areas, Before-After studies, ...), the **Qualitative Appraisals** (Key

Informants, Delphi technique, ...), the **Forecasting Models** (urban, economic, dynamic simulations), the **Statistical Analysis** (econometric, regression, correlation technique). The difficulties of the analysis are those specific to urban studies because of:

- **Long-time effects** (Changes on land use occur over long-time periods, so they are difficult to be managed);
- **Addition of the effects** (Difficulty of separating principal and secondary effects);
- **Availability of data** (existence, reliability, availability of data).

The methods and tools used in different experiences to control transportation policies and land-use changes are numerous. They operate at different levels:

- **Expropriations** (acquisition in advance of station and route areas);
- **Lease or Rent of air rights** over the areas;
- **Joint Development** (public-private cooperation);
- **Zoning** (location of residences, services, and workplaces);
- **Design** (Station layout, density, typologies, urban structure,...);
- **Taxes** (Fuel, parking, tolls);
- **Financing** (per sector, shared per mode, per type, per efficacy, ...);
- **Management** (Demand Responsive Transportation Systems, Car pooling, staggered hours, routing, scheduling, ...).

All the available tools must be used in an 'aimed policy', integrating the effects of each other.

Finally, it is hard to balance an appropriate range of policies to cope effectively with the local urban-transportation problems. The same policies could result differently effective in different situations

(for instance, see **Hutchinson, 1986a** and **1986b**, comparing the structural changes in the Sidney and Toronto regions).

As a matter of fact, some final remarks can be made from the analysis of the most significant American experiences:

(1) The first condition for using transportation investment and policies as an occasion to stimulate urban development is the existence in the region of a positive **economic trend**; the development does not only occur because of transportation facilities.

(2) Another strategic element of a successful result of policy and planning processes is the existence of an effective role for the **metropolitan government.** The range of phenomena and necessities of public policy require an adequate level of government.

(3) The co-existence and availability of a **series of factors** are necessary to get an effective impact of policies: land, investments, infrastructure provision, zoning and other incentives, ..., are indispensable.

(4) Often the lack of physical impact hides the existence of an important series of **non-physical changes**; as changes in the style of life, changes in the use of the city, the role of CBD, re-use and renewal of buildings, ...

(5) There are many other issues that can justify choices of a public transportation policy, in terms of **quality of life** and **quality of the environment**; as freedom from cars, importance of other modes like bikes and pedestrians, recognizability of urban paths, the 'image of the city', ...

(6) For all these reasons, transportation and land-use planning must be organized systematically in a **"Local-specific"** policy, according to the stated goals and objectives.

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